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Deployment of full-body scanners at airport security checkpoints is being stepped up across the country. As flight crews, we are occupationally exposed to more radiation than the general public, and therefore need to be informed about this equipment. Kristina Huffman, M.M.Sc., D.A.B.R., a board-certified radiological physicist and a commercial pilot with Alaska Airlines, has written an excellent article detailing this technology and answers many of our questions. Currently, ALPA does not have an official policy on full-body scanners. The Aeromedical Committee is in the process of gathering more information and, as always, highly recommends that pilots discuss all their medical concerns with their personal health-care professional. It is important that your doctor understands your complete medical picture, taking into consideration your personal health needs (number of x-rays), family history, type of flying (polar or low-altitude flights), and your personal lifestyle (sunbathing and outdoor activities).

*Fly Safe! Stay Healthy!*

Captain R. A. Solik  
Aeromedical Chairman

## Advanced Imaging Technology for Airport Security Screening

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Full body scans utilizing advanced imaging technology are now being performed as part of routine airport security screening. At the present time, 44 imaging units are in use at 21 airports across the United States.<sup>1</sup> Images created by the full body scanners currently employ two different types of imaging technologies. Of the 44 imaging units currently in use, 40 of them utilize millimeter wave technology to form images that reveal concealed objects. The remaining 4 scanners employ backscatter X-ray technology to also form images capable of revealing concealed objects. In March 2010, the TSA stepped up its use of body scanners, deploying an additional 150 backscatter X-ray imaging units. In 2010, the TSA plans to implement a total of 450 advanced imaging units at airports across the United States. While controversies surround privacy issues associated with security imaging, professional organizations such as the American College of Radiology and the Health Physics Society have released position statements citing that no significant health effects are associated with the newly implemented imaging technology in security screening.

The most common imaging modality employs backscatter X-rays. Backscatter X-ray technology makes use of low energy X-rays to create an image of the body surface. All familiar medical imaging procedures utilize transmission X-rays with sufficient energy to penetrate the human body, thus creating an image from the transmitted X-rays. The energy of X-rays associated with backscatter technology is lower, so that images are created from X-rays scattered off the body surface and not transmitted through the body. The backscatter X-ray scan uses X-rays that are projected in front and behind the individual, resulting in two-dimensional images of the front and back surfaces of the individual.

Since the TSA has implemented a plan to increase the number of backscatter X-ray imaging units, concern has been raised regarding the radiation exposure associated with the

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<sup>1</sup> TSA: Imaging Technology ([http://www.tsa.gov/approach/tech/imaging\\_technology.shtm](http://www.tsa.gov/approach/tech/imaging_technology.shtm)).

*Radiation exposures from backscatter X-ray scans conform well below the ANSI limits for radiation exposure.*

technology. Radiation exposure from a backscatter X-ray scan is reported to deliver a dose of approximately 0.05 microsieverts (0.00005 millisieverts) per scan.<sup>2</sup> In the United States, X-ray systems used for security screening purposes must comply with the American National Standards Institute (ANSI) standards for radiation exposure set forth in Standard N43.17-2009.<sup>3</sup> These standards specify the maximum permissible dose as 0.25 microsieverts (0.00025 millisieverts)<sup>4</sup> per scan for individuals of the general public. Additionally, ANSI specifies the maximum permissible effective dose to an individual of 250 microsieverts (0.25 millisieverts) per year at a given screening facility for the general public. Radiation exposures from backscatter X-ray scans conform well below the ANSI limits for radiation exposure. Exposures from a single scan equate to roughly 1.5 hours of natural background radiation from sources in the air and soil, which is also the equivalent of 2 minutes of in-flight exposure from cosmic radiation sources at an altitude of 30,000 ft.<sup>5</sup> As a general rule, individuals receive an average dose of 3.1 millisieverts from all background radiation sources each year.<sup>6</sup> The table below includes a comparison of radiation doses from the current types of imaging modalities that employ ionizing radiation. The exposures from these technologies are contrasted to ANSI standards as well as traditional medical procedures and other background radiation sources for comparison's sake.

Radiation Exposure	Exposure Received (Millisieverts)
ANSI standard limit for screening scan exposure	0.00025 per scan, 0.25 per year
Occupational exposure limit	20 average/year, 50 max in any one year
Backscatter X-ray security screening scan	0.00005 per scan
Transmission X-ray security screening scan	0.00025 per scan
Millimeter wave security screening scan	0.0 per scan*
Average exposure from a chest X-ray	0.06 per X-ray
Average exposure from an upper GI X-ray study	2.45 per study
Average exposure from a chest CT scan	5.8 per study
Average exposure from a nuclear medicine thyroid scan	0.14 per study
Exposure from having a smoke detector in the home	0.00008 per year
Exposure from having porcelain crowns on your teeth	0.0007 per year
Exposure on a flight from New York to Seattle at FL390	0.028 per flight
Average exposure from all natural background radiation	3.1 per year

\*Note that millimeter wave imaging uses non-ionizing radiation and does not result in exposure classified in millisieverts

Airline pilots typically receive between 0.2 and 9.1 millisieverts of additional dose each year from in-flight radiation sources, with the range of doses resulting from differing flight routes and times aloft.<sup>7</sup> Flight crews are classified as occupationally exposed to radiation,<sup>8</sup> so their recommended limits for exposure fall under limitations established specifically for the occupationally exposed individual. The recommended limit for occupational radiation exposure, published by the International Commission on Radiation Protection in 2007, is a five-year average of 20 millisieverts with no more than 50 millisieverts in any one year<sup>9</sup> (note

<sup>2</sup> Health Physics Society; McLean, VA.

<sup>3</sup> American National Standards Institute (ANSI) Standard N43.17-2009, "Radiation Safety for Personnel Security Screening Systems Using X-rays or Gamma Radiation," August 2009.

<sup>4</sup> Note that 1 millisievert = 1,000 microsieverts.

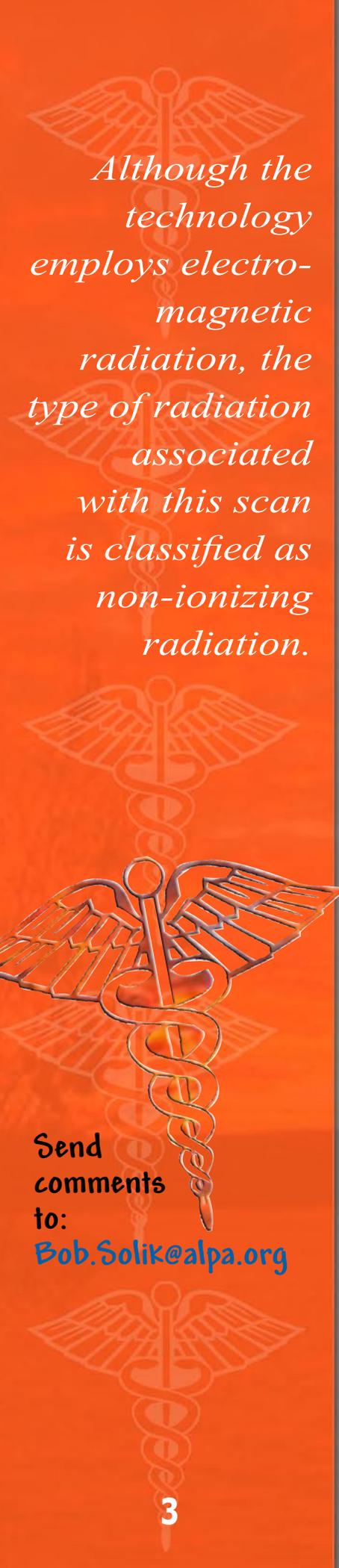
<sup>5</sup> U.S. Environmental Protection Agency Radiation Dose Calculator (<http://www.epa.gov/rpdweb00/understand/calculate.html>).

<sup>6</sup> Health Physics Society, Environmental Radiation ([http://hps.org/documents/environmental\\_radiation\\_fact\\_sheet.pdf](http://hps.org/documents/environmental_radiation_fact_sheet.pdf)).

<sup>7</sup> US DOT FAA Advisory Circular 120-52, 3/1990.

<sup>8</sup> International Commission on Radiation Protection (ICRP), 1990.

<sup>9</sup> Draft Recommendations of the International Commission on Radiation Protection (ICRP), 1/2007 ([http://hps.org/govtrelations/documents/icrp\\_2007recommendations\\_draft\\_1-12-07.pdf](http://hps.org/govtrelations/documents/icrp_2007recommendations_draft_1-12-07.pdf)).



*Although the technology employs electromagnetic radiation, the type of radiation associated with this scan is classified as non-ionizing radiation.*

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that these limits are higher than limits set for the general public). To calculate the maximum number of backscatter X-ray scans that a flight crewmember could receive that would result in the maximum annual occupational exposure limit, one would take the difference between the highest estimated exposure from in-flight radiation exposure and the maximum recommended exposure for occupationally exposed individuals. The resulting difference is 10.9 millisieverts per year. In order for a crewmember to receive 10.9 millisieverts of radiation from backscatter X-ray scans, he or she would have to be subjected to 218,000 scans per year, which equates to an average of 699 scans per day (calculated over a 6-day work week, 52 weeks per year). Given the number of scans that would be required to reach this limit, it is a safe assumption that this limit is unachievable even by the most active crewmember. While these limits apply to occupationally exposed individuals, one needs to keep in mind that limits for occupational workers who are pregnant are subject to different recommendations. Current recommendation set forth by the ICRP for pregnant workers is 1 millisievert over the course of a pregnancy.<sup>10</sup> Given these limits, full body scans could pose different challenges for pregnant crewmembers, which is beyond the scope of this article.

The second type of advanced imaging technology utilized by the TSA employs high frequency radio waves. Millimeter wave technology creates a three-dimensional image of the body, revealing concealed objects beneath clothing. Electromagnetic radiation in the high radio frequency (terahertz) band is transmitted simultaneously by two coils or antennas, which rotate around the body during the scan procedure. Although the technology employs electromagnetic radiation, the type of radiation associated with this scan is classified as non-ionizing radiation. The electromagnetic wave that is reflected from the body surface is processed to form a three-dimensional image. While the electromagnetic radiation is not considered ionizing, researchers are currently investigating the health effects of terahertz radiation exposure. The American College of Radiology (ACR) released a position statement in January 2010, citing that the technologies associated with both scanning modalities are not considered to present significant biological effects for screened passengers.<sup>11</sup> Results from research conducted at Los Alamos National Laboratory suggests that terahertz radiation exposure may affect DNA dynamics, impacting processes associated with gene expression and DNA replication.<sup>12</sup> Current position statements by national organizations suggest that the risk associated with such scans may not significantly increase the risk of adverse health effects. Further research may be warranted to investigate the proposed risk suggested in preliminary studies, especially given that debate still exists over the safety of this form of imaging technology.

A third form of advanced imaging technology is not currently in use in the United States but is being employed in at least seven countries, thus potentially impacting crewmembers flying on international routes. This technology is similar to backscatter X-ray technology, but instead utilizes transmission X-rays. Transmission X-ray scans create an image from X-rays that pass through the body. This technology is similar to that utilized in medical imaging procedures, and allows security personnel to image internal cavities for items concealed within the body. These systems appear to be less frequently used for routine imaging and to be reserved for situations in which passengers raise concern of concealed objects within body cavities as a result of aberrant behavior. Radiation doses from transmission X-ray scans, while higher than backscatter X-ray images, still only result in approximately 0.25 microsieverts (0.00025 millisieverts) per scan. The radiation doses associated with this imaging modality still conforms to ANSI standards and is well within accepted limits for exposures per scan. For comparison purposes, a crewmember would need to be subjected to 4,360 transmission X-ray scans annually (or 14 scans each day on a 6-day work week, 52 weeks per year) to reach his or her recommended limit for occupational exposure. As with backscatter X-ray technology, transmission X-ray imaging is generally accepted as posing no significant health concerns.

<sup>10</sup> Galactic Cosmic Radiation Exposure of Pregnant Aircrew Members II, 10/2000 ([http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/00\\_33.pdf](http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/00_33.pdf)).

<sup>11</sup> American College of Radiology (ACR), 1/2010 ([http://www.acr.org/MainMenuCategories/media\\_room/FeaturedCategories/PressReleases/StatementonAirportFullbodyScanners.aspx](http://www.acr.org/MainMenuCategories/media_room/FeaturedCategories/PressReleases/StatementonAirportFullbodyScanners.aspx)).

<sup>12</sup> Breathing Dynamics in the Presence of a Terahertz Field, 10/2009 (<http://arxiv.org/abs/0910.5294>).